Oral History of Burton Grad—General Electric Years

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Table of Contents

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Conducted by Software Industry Special Interest Group

Abstract: Burt Grad describes his career at General Electric during the 1950s. After starting on the Manufacturing Training Program in 1949 with assignments in various locations, he went to work in the Large Steam Turbine Department in 1950 where he had production control responsibilities including learning to program and use punch card equipment. He then joined GE's Production Control Services headquarters function in 1954 where his first assignment was to prepare production control programs for the Univac I at the new GE major appliance factory in Louisville, Kentucky. Following a series of inventory control, scheduling and factory simulation projects, Burt then started the Integrated Systems Project which was targeted at automating the complete information flow in a non-assembly line plant. When the first effort at the 39 Frame Motor plant was discontinued in 1957, the work then continued with a team of 40 people at the Meter plant in Lynn, Massachusetts and incorporated some elements of factory automation with numerically controlled machine tools. Among the ideas developed during this project, Decision Tables turned out to be a very valuable tool to record and then program the logic needed to engineer the parts and assemblies, determine the manufacturing processes to follow and to cover all of the other information functions to carry an order from receipt to product completion and shipment. When GE would not pursue implementing these information integration ideas and would not permit the publication of the findings, Burt decided to leave GE and go to IBM. In the interview, Burt also describes the use of Decision Tables in some detail and talks about GE's venture into the computer business and why he believes that not only GE, but most of the other competitors to IBM were unsuccessful during the 1960s and 1970s.

Mike Marcus: I am Mike Marcus and I'm interviewing Burton Grad. It's January 19th, 2010 and we're in Sanibel, Florida. This interview is part of the Software Industry Special Interest Group's Oral History Project. This interview of Burt will cover the period 1949 to 1960 while he was at the General Electric Company, which was his first job after college. Burt, let's start by you giving a little background about the college courses you feel were most useful to you in working at GE and then follow up on why you decided to go to GE.

Starting Work at General Electric

Burton Grad: Mike, I went to Rensselaer Polytechnic Institute [Troy, NY]; I started in November1945 as a physics major at RPI. I decided after a couple of years there that the guys who were majoring in physics were just a significant notch smarter than I; they were better mathematicians and better at what they were doing. And since I always like to be pretty good at what I am doing I decided at that point I would like to consider some alternatives. After talking to one of my uncles, he suggested I consider business courses. At that point, RPI had just introduced a new program called Management Engineering, which was really an expanded industrial engineering program with a new name. And they did introduce a broader range of subjects, not just focusing on time and motion study and the physical operations in a factory, but they were dealing with a lot more business issues and marketing. So I took that as my major the last two years while I was at college. I graduated in January of 1949. The management engineering program was unusual in that it gave me a choice of minors. I decided to minor in physics which meant I could take a course in any of the engineering or science areas; I wasn't limited to electrical engineering or mechanical engineering or chemistry or any of those specific areas. So I ended up taking one course in almost every one of the areas: a course in transportation, a course in electronics, a course in nuclear science, a course in chemistry. So in a sense I had a very broad background in a whole range of different disciplines.

I had interviews with a number of companies and I had a couple of offers. This was 1949 in January, before the Korean War, and there were still plenty of job opportunities. By the middle of 1949 that whole climate had changed dramatically so I was very lucky in that regard. The two that I was most interested in were Corning Glass in Corning, New York and GE. And GE was sort of a neighbor since it was headquartered in Schenectady, NY only 20 miles away from Troy. I particularly liked the proposed training program that was a new program at GE called the Manufacturing Training Program. They'd always had what they called Test Program because when you came in as an engineer you went through a series of test assignments. You went to work at different departments within the company and you ran tests there; you would test motors or electronic gear In whatever division you were in you'd run tests of the products that they produced. In this way you would be able to learn a bit about the products while they could learn a bit about you; you also learned about the company and at the end of the test program, which typically lasted a year, you would either have made a connection with one of the departments that was interested in hiring you or you knew what departments you would like to go to for interviews.

The Manufacturing Training Program (MTP) was their idea of trying to pick up people in this industrial engineering field, not just the product engineers with electrical, mechanical or chemical engineering degrees. This sounded good to me. But as it turned out MTP hadn't been defined when I got there, as this was the first year they were going to run it. So they just put us in the test program exactly the same as they would any other engineer. Nevertheless, I did have some extra flexibility. They were willing to give me assignments in areas that would have more relationship to my management engineering degree and provide more manufacturing engineering experiences.

Marcus: So just to clarify -- the fact that the word training is in there, "manufacturing training," doesn't mean that it was a training program where you would learn to be a trainer, it was for the training of people coming into the company, is that right?

Grad: Yes, it was their means of getting you on board. In a sense, it's just like working in a law firm or someplace else where they give you a series of assignments to start with. I decided to take the job. But first I got married and went on our honeymoon for two weeks and then went to work for GE. The first work location was in Bridgeport, Connecticut and the initial assignment was to test the rubber that was being used to wrap the wire and cable that they were producing in that plant. This was a major facility and the testing process was that you took these strips of rubber, put them between two jaws of a machine which stretched them and as soon as they broke you had to read the breaking point and record it to see if it would match the tensile strength they were looking for on these products. There were five people working there, four union people and me.

After I had been about two, three days, I said, "This is ridiculous. I have to watch one machine because I have to see just when it breaks because the needle goes right back to zero as soon as it breaks and you have to catch it as it breaks." This seemed foolish to me so I came up with the idea that if you put a grommet on the dial, the needle would push it up and once the needle fell back the grommet would stay in place, so you knew what the reading was. Therefore, one or two people could run all five of the testing machines just by going around clamping in the rubber strips and then reading off the numbers. I put it in as a suggestion and got an award of 150 dollars and the union practically went on strike. They were not very happy that I eliminated four union jobs in the process. But for whatever reason it did show me that that was the way I thought about how things operated and could see how to change them.

The other thing that happened in Bridgeport was totally accidental. There was a gentleman there named Dr. Frank Satterthwaite who was from the University of Iowa, at Ames; he had his PhD in statistics and he had been doing studies on how one did quality control sampling because you couldn't test every single product. You wanted to sample the products from a lot and if the tests came out well enough you could go ahead and accept the entire lot. He had the idea that the sampling tables that were in use, the Dodge-Romig tables, were seriously wrong. These had been used prior to and during the Second World War for product acceptance.

Marcus: What were these tables for?

Grad: These were used to select a sample size, 5 or 10 or 20 units of whatever you're sampling, and depending upon the results of your test you would decide whether to accept the lot of 1,000 or 10,000 units. And they had what they call the small s, and large S. If the number of good ones was above a certain number you accepted the lot; if the number of good ones was below a certain number you rejected it; if it was in between, you tested some more. Dr. Satterthwaite felt that the parameters didn't differentiate between the cost of rejecting a good lot by mistake or accepting a bad lot by mistake. He felt that there was no value function in these tables. And literally everybody in the world used these Dodge-Romig tables to determine sample size and whether the lot should be accepted or rejected. The United States used them during the war for all the products going into planes, all the military equipment, everything.

Dr. Satterthwaite reformulated the underlying mathematics and I happened to be there in Bridgeport and he asked if I would like to work with him. So I worked with him on the statistical analyses and he came up with a complete new set of formulations which to my mind, and then to many others, proved that the tables were dead wrong. His point was if you had some part that was going to be in an airplane and that part failed, the cost could be unbelievable depending upon the nature of the failure. The plane could crash, it could kill people. He then constructed a new set of sampling tables that had formulas built in which took the relative values for accepting a bad lot or rejecting a good lot into account and that dramatically changed the sample size and acceptance criteria for sensitive products. He was generous enough to put my name on the paper. So I had a published paper within the first year of my working at GE. The paper was published in the Statistical Journal.

Marcus: So in a sense, the previous tables took into account the risk and what he added was the liability if that risk occurs.

Grad: And it changed significantly the sampling for highly sensitive electronic parts, things for airplanes or nuclear power. In those cases you don't go with the normal sampling, you have to sample at a completely different level. It was big fun. And then again, this is all within my first assignment which lasted only three months. So I was there for a relatively short time, but at the time they had a problem in building washing machines with high speed spin cycles to dry the clothes. And almost every one of the new machines was breaking down because they were going off kilter during the dry cycle and becoming damaged. I was asked if I wanted to tackle this problem because I had a statistical background; did I want to go down to Philadelphia, look at all the data they had accumulated on the problems, the complaints and examine the units coming back to help them determine what was wrong so the engineers could figure out a fix.

So I went down to Philadelphia for I think four to six weeks and examined all the statistical tables, did the statistical analysis and came back with the report as to what was wrong. The springing was just not good enough and they had to replace the springs in all the washers that were out there. And that made a big difference because, those spin speeds were very high and they were just not used to handling that in a home appliance. So in the first three months I had three different assignments that I worked on and it was quite an experience. Because I had worked on the rubber testing for wire and cable they offered me an opportunity to have a test assignment in York, Pennsylvania at another wire and cable plant. They asked if I would be willing to go to York and set up a quality control system for the wire and cable plant there.

Marcus: Pretty good for a trainee.

Grad: It was ridiculous. They had no business sending me there. And if I had been smart enough or less self confident I would have said, "Hey, I can't do this." But I guess when you're young and you're just out of school -- I had just turned 21 -- and I figured, what the heck. So my wife and I moved to York, Pennsylvania, rented a top floor apartment there and I went into the factory. Again, it was highly unionized. GE was just highly unionized everywhere. The union actually was a communist dominated union called the United Electrical Workers. And there was a great deal of conflict between management and union. So one had to be very careful what one did in a unionized shop and here I am trying to set up a complete quality control system. During the next three months we did everything from incoming inventory sampling, in process checking of the machines as to what they were doing, and completed product testing, to make sure that the wire and cables and the insulation was what it should be. So we set up a comprehensive quality control system from beginning to end within that three month period. It was an incredible experience and one I still am surprised I was able to do it.

It turned out that the background and the range of courses I took at RPI in the Management Engineering program had given me a little bit of knowledge in almost every area that GE was involved in. They were in nuclear, they were in electronics, they were in metallurgical with the carbide products; they were in every one of these areas. And of course, I took courses in manufacturing and while I was there and in marketing. So it was surprising to me that these things all fit together, that wherever I walked in I had some of the terminology I needed to help me understand and work with the people. That was very special and I think if I hadn't had that background I don't know if I would have been able to do these things.

Marcus: Let’s talk about what happened once you were out of the training program.

Grad: I just had a couple more assignments. The last two were in Schenectady, which was GE’s largest location at the time. And I worked on a motor and generator testing stand. We were testing the valves used to provide oil flow to the shafts so they didn’t seize up. I saw the testing process there and I didn't feel it was very efficient and I came up with another suggestion on how to improve that and eliminate some more union jobs.

Marcus: They accepted that?

Grad: Accepted that one too; I don't know if the union accepted it but the company did. I got another award for that. So then I ended up in the large steam turbine department as my last assignment. That was the largest single factory in Schenectady, Building 273; it was mammoth. These steam turbines are very large and the rotors themselves are 100 feet to 150 feet long; they are large heavy pieces. And the tests involve spinning those things up to 3,600 rpm and then checking the rotors to make sure that there's no vibration so that nothing is going to go wrong with them. They had them in pits, sort of partly down underneath the ground, and you as a tester went down into the pit so you could do the measurements on the rotors. There were electrical measurements, a whole bunch of things, but a lot of it had to do with putting a sensing device on the rotor so that you would be able to pick up any kind of odd vibration. And one night, when I happened not to be working there, one of the rotors blew up. Fortunately there were not any people in the offices since pieces of these steel rotors went through the roof of the building and back down through the offices which were in the front of the building; there were no deaths, but that was just pure luck. So those testing assignments had some risks involved. I was very pleased I wasn't there. You work shifts. I had been working night shift but I wasn't on the particular night that this occurred.

Marcus: Were you involved in anything that GE may have done afterward to make the situation safer?

Grad: I didn't get involved but they did a lot obviously. What they started doing was to extend their static sonic testing and they started doing more of that, checking the entire rotor to see if there were any cracks before running it at full speed. But I was not involved in that. While I had been at the Large Steam Turbine factory, it appeared to be a very active operation with a lot of potential in the manufacturing control area. So when I was looking for a job, I started interviewing there in the production control area and ended up getting offered a job by a man named Nelson Coutant. He was the director of production control or production management, whatever they called it at that time. And he said, "Well I'm going to start you by putting you on a series of different assignments." So it was sort of like an extension of the Manufacturing Training Program.

Production Control at Large Steam Turbine

Grad: This was a big factory, with a lot of different manufacturing aspects and production control was involved in setting the factory schedules, dispatching the jobs to the work stations, working with the manufacturing engineers, all of those kinds of things. So two of my first assignments were as a dispatcher and then as an expediter. There were 10 or 15 turbines that were in process at any one time so the parts for each and the assemblies take up lots of room. Thousands of parts went into each turbine; there were thousands of rotor blades for each rotor. There were the windings that go around for the stator; there were literally tons of small hardware and parts needed to build a single turbine.

Marcus: Was it your responsibility to expedite the total process or some subset of the process?

Grad: That's a good question. One responsibility was that they gave me certain orders to follow. Detroit Edison for example was one that I had. They had a big unit being built there. I was responsible for working with the Detroit Edison people when they came in to Schenectady to bring them up to date on where everything was, what was falling behind, how we were catching up, were we in good shape and so forth. They would come in about once a month and I was responsible for meeting with them. They liked to drink their lunch; I didn't know how to drink and still don't. But I was supposed to go out with them and entertain them, make sure they didn't cause any mischief or cause any problems when they went back home to Detroit. That was one part of the job. The other part of expediting was that they would give me hot lists of things that were falling behind schedule -- parts, assemblies, things like. And I was supposed to go out to the various dispatch cages that were around the factory, find out the status of these parts, what the trouble was and see what I could come up with to get it back on schedule. In some cases they needed certain materials that weren't there or they needed some parts for assembly that weren't there. I was supposed to get after the purchasing people, get after the vendors, and check the other work stations and get those parts in to get them fixed.

Marcus: Was this a one man show or did you have help doing this, either administrative help or technical help?

Grad: I had four people working for me to help me do this, the staff. And these were all older people obviously because I was still 21 years old at this point. They were not unionized and they were supposed to work for me and I was supposed to guide them.

Marcus: So it sounds almost like in the Army where there's a two tier system. There are the commissioned officers and then the enlisted people and you seem to have come in sort of the equivalent of a commissioned officer and these other people were like enlisted people.

Grad: You're exactly correct. I was being clearly trained to be a manager and I was being given that kind of an assignment. I hadn't thought of that analogy, but it was clearly the same concept, these were white collar workers, the ones I was working with, but they were reporting to me, it was my responsibility. And of course, this is where I ran into my first serious problems that weren't union problems.

Marcus: Well that's interesting; in the Army, I can tell you from firsthand experience and from others that smart young commissioned officers know to listen to their sergeants. And in most cases those sergeants were really grizzled old timers and usually very helpful. What was your experience in dealing with these people?

Grad: They weren't of the same caliber as the really good master sergeants and other non-commissioned officers. They were workers, they were plodders. If they had been really good they would have probably moved ahead. But these men, one man was in his 50s and another in his 30s, but they all seemed very old to me at the time. But they were just plodders, they made a living, they got a good wage and they did what they had to do but they weren't pushing. But I was a pusher. And this led to some problems. I remember still being called in by Nelson Coutant and he said, "You're going to have to learn something. Everybody's pissed at you. Nobody's happy. You've got to learn to make them like you and you've got to learn to not push them harder than they're willing to be pushed." And as you can imagine, Mike, that was a very important lesson for me. I never learned it well but I did adjust.

As a result, we cleared up a tremendous backlog. They were really having problems. And how much of that was caused by union activity, it was hard to tell. The UEW union was unhappy, they were going to strike GE shortly so there was, I won't say sabotage, but there was certainly nobody knocking themselves out to fix things. But these staff people weren't unionized, so we got through the backlog list very quickly. Another assignment was that I ran what's called a dispatch cage. I was out on the factory floor, with three or four other people working in that dispatch cage (it literally was a metal cage around you) and you gave out the vouchers to all the labor people. All the operators were on piece work; all these guys who were running the lathes and all the drill presses, all the machines in this place, all worked on piece work.

Marcus: So they are almost the equivalent of internal contractors if this is like piecework.

Grad: These are all employees, union employees, but the contract was, you're paid by the particular piece you produce, no guarantees, no anything. You got your medical coverage and you got some other things, but you were paid by the piece. You did these 10 pieces and if they passed quality control you got your $2.73 for each piece.

Marcus: So you were in a position then to hand out these vouchers to whom you chose.

Grad: No, it wasn't that I chose, you had rules on dispatching and that was the interesting part. Which of the vouchers do you want to give out. You knew what your schedules were, you knew what you had to get done and you knew who was available to take on a new job. I learned something from that that I applied later on. If you really want to get production out, you sometimes have to put the quickest jobs out there, get them out of the way so it could move other things along. It wasn't just first in, first out, or one which had the highest priority or “best” prices. Every voucher had on it the date that it was supposed to get done and you knew the time required to do the job and you knew the money that was going to get paid and you knew what skills were required. And the machinists, the union guys, always tried to job you. I don't blame them, but each of them said, "I want the easier jobs." Some of the jobs were known to be easy jobs; you could get them done easily and pick up extra money by getting five jobs done in a day instead of three or four.

Marcus: How long were you in that position?

Grad: Probably three months.

Marcus: So how did you learn all the things that these guys knew about how to game the system?

Grad: I did have people to advise me and suggest, "This guy's a so and so, watch out for him, he's always going to say, “Oh I can't do that, I don't have a special drill.” They told me not to listen to him. They said to give out the job you think should be given to that station. The part that was trickier though was which ones to give out because if you followed strict order you ended up with large backlogs, with gridlock in places because the next guy along the line wouldn't have the things he needed. So you had to sort of look ahead and see what else was going to happen in all your area and then in the other areas that you weren't controlling.

Marcus: So in a sense there's another case in which there's a sort of what's the overall value of doing this versus something else, so it's value oriented.

Grad: Yes, and I don't remember how I picked all that up, but I do know that we ended up doing very well against the various measures of performance, meeting schedules, a relatively few number of late jobs and so forth. It was an exciting experience. I then end up doing regular production control work such as factory scheduling and planning, working with manufacturing control. And we were starting get into a lot of punch card work because all of our production control work was not yet automated. They wanted to bring in punch card systems but it hadn't been done before in Large Steam Turbine (and maybe not very much anywhere in GE). The accounting people had been using punch cards, they had used them extensively, but we had virtually no experience in them. The vouchers were all basically run off of a mimeograph machine that produced multiple copies of pieces of paper. There was no automatic processing. So, I worked with a fellow named Bob Smiley in accounting who taught me how to use punch card equipment and how to wire plug boards.

Marcus: And whose equipment was that?

Grad: Oh, IBM of course. No one bothered with Remington Rand since they had only 10 percent of the market, so who cared. But it was all IBM machines and I learned to use punch card machines, I learned how to plug boards, I learned how to do all those kind of things at that point in time. And we set up a manufacturing control plan for the Large Steam Turbine department to produce the vouchers to be given out to the factory workers, all to be done by punch card machines instead of being done by hand typing and so forth. You can learn so many things in doing that and that got me deeply into the punch card area. I started working with some of the engineers because they were using punch card equipment to do some of their calculation work. I started in 1949, went off the training program in 1950 and by the beginning of 1954 I had been heavily involved in using punch cards for a couple of years and they were terrific. You could get incredibly complex stuff done with punch card equipment, using the 407 printers and the 604 calculating machines. I did my first programming in a sense then because you had to plug a board which is a sequence of steps on the 604s, but it was only 40 steps so it was easy. You couldn't iterate so you had to make sure it got done linearly, but it got me acquainted with the idea of programming.

Production Control Services

While I don't remember exactly how the next step took place, there was an opportunity in what GE called Production Control Services. GE had divisions and departments within divisions; for example, the Turbine division not only had the Large Steam Turbine department but they also had Small Steam Turbine and Medium Steam Turbine departments. They must have had maybe 100 of these departments around the country. And what GE had done was create a services staff; these staff groups were located in New York City where GE corporate headquarters was located. And each of these services specialized in one of the functional areas. Every GE department was pretty much organized exactly the same way. There was Finance and Accounting, Engineering, Sales and Marketing, Personnel, etc. Manufacturing included Manufacturing Control, Manufacturing Engineering and those functions. It was a totally functional organization within each of these departments. The department might be Small Motors or Medium Motors or Large Motors or whatever, but no matter where you went in the company, that functional structure was always there.

This is a side story that I'll mention in passing, although it's not related to the substance of what I was doing. GE since the 1920s or so had had a special retreat every summer for their management people in the Thousand Islands area in upper New York State, on the St. Lawrence River and this was by invitation only. This was a very formal thing, and the location was called Association Island. Everybody was assigned to teams to compete in various sports. This has been described and parodied in a book called *Player Piano* by Kurt Vonnegut where he describes Association Island. He changes the name, but this book is basically about GE in Schenectady. And I was invited to go there in 1953 because I was in management then. And you had an Indian arriving in a canoe to welcome you to the islands; you had the red team and the green team and all kinds of contests and games. That was the last year they had it. They sang the songs, you did all these kinds of “bonding” things, but that was the end of it. Many of the large companies had those kinds of relationships and this type of event. IBM had the same kind of event for many years. But this was the last year at GE and I happened to be there. It's described in a book about IBM, which shows the pictures and activities from that year.

Marcus: Going back on what you said, it looked like GE then was organized functionally.

Grad: Every department was functional so when the services were set up, what they set up was a service corresponding to each functional area.

Marcus: Okay. So did they have things that are the equivalent of projects where functions had to be integrated and if they did, how did they do that?

Grad: That was not done well. That was one of the major issues and problems. Each of the functions was a fiefdom, each of them worked independently. For example, when we were working in production control we did our thing, we didn't do manufacturing engineering's thing even thought it was a cousin group, we didn't do the accounting thing, we didn't do anything else; we didn't tie them together, they were all independent operations. That'll lead to something we'll talk about later on. Because that was the nature of the way they did things, they did not view the systems on a project basis; they viewed them as serial operations: engineering passed product design information to manufacturing; manufacturing engineering passed information to production control. Cost accounting was separate; there was no integration across the board.

Marcus: No equivalent of matrix management or any of that stuff?

Grad: Zero.

Marcus: Interesting.

Grad: At corporate headquarters now, these services groups were set up in an exactly corresponding structure. There was Manufacturing Services with Manufacturing Control Services as part of it and then there was Production Control Services as part of that. It was the same hierarchal chain that you had within the individual departments. And that was true in Finance, where you had General Accounting and Cost Accounting; the services were exactly matched. Same thing in Engineering, everything was matched.

Marcus: Just to get ahead of ourselves, did it remain that way for your tenure at GE?

Grad: Yes, it did. And during my last few years at GE, I was working on a project to try to break all those barriers down and that's what we'll come to in the late 1950s. I was trying to get people to view the department as an integrated system; it should be viewed that way and not as a series of independent functional areas. And let me tell you, the opposition to that was very substantial to say the least.

Marcus: Entrenched positions I assume.

Grad: Heavily so and for good reason because you came up through a functional organization and you didn't get out of that organization. The people who ended up running some departments were always engineering people who came to the top. In other departments it was the marketing people who always came to the top. In still others, it would be accounting or finance people who always came to the top. It was a very structured thing. Ralph Cordiner was the president of GE during that time; he was a fine gentleman, a very astute gentleman and he ran the company well. He had taken over from a gentleman who was somewhat of a bull in a china shop. There were two Charlie Wilsons during the Second World War, one was running General Motors and one was running GE. So you had electric Charlie and you had automobile Charlie and they were both very, very strong individuals. Charlie Wilson from GM said that what was good for General Motors was good for the country. Charlie Wilson at GE was smart enough not to say that. He may have believed it, but never said it.

One thing to understand is that GE in the 1950s was in a wide range of manufacturing areas, I'd say about 100 different departments. It was heavy in nuclear power with the Knolls Atomic Power Lab and they were starting to build nuclear power facilities. They had aircraft gas turbines, the GE engines which powered many of the new jet airplanes. They were heavily into metallurgy with tungsten carbide which I believe they called Carborundum. They were into electronics, with tons of electronic gear being built in Syracuse and elsewhere. You name it and they were in it. They were in the chemical stuff which eventually led to the plastics business. They got into the x-ray business. Each of these were well defined areas -- small motors, medium motors -- whatever you were talking about would be in a particular location. Fort Wayne had certain kinds of small motors. In North Carolina, you'd have somebody doing particular kinds of electronic controls. The exception was appliances. They had the major appliance division, which was making washers, driers, stoves, those kinds of things; and they even had their own internal competition with Hotpoint in Chicago. They had small appliances in Bridgeport and some other places making toasters and waffle irons and things like this. This was a company with a wide ranging set of things and significant requirements for technology, for engineering, for manufacturing engineering and for manufacturing control. Of course, there were assembly lines for high volume products, but also individual job shops with piece work production all over the place as well. It was a fascinating mixture. In Large Steam Turbines we had a big job shop with everything being done to order. You weren't building to inventory fundamentally.

So, back to my story. I was offered a job to come down to New York City and work for Production Control Services and that sounded like a lot of fun. And I took it. I started in the middle of 1954. We were located at the GE Headquarters building at 570 Lexington Avenue in New York City. Very soon after I got down there, before I really got into much of anything, GE made the decision to be a leader in the adoption of computers. They were not in the computer business, but they were building this mammoth new facility in Louisville, Kentucky to make all their major appliances. It was to be state of the art in terms of a manufacturing facility.

Marcus: What did they manufacture there?

Grad: Every large appliance -- stoves, dishwashers, disposers, every large appliance. There were five different departments located in Louisville in a very high class building which was beautifully designed and architected. It had the most modern automated machines, assembly lines, all these kinds of things were part of what they were doing. GE decided they were going to be the first commercial company to have a computer. The Univac I up to that point had only been sold to two government agencies. The Univac I was introduced in 1952 for the presidential election where it got a lot of publicity and attention by predicting Eisenhower's victory quite early, when no one would believe that he was going to win by that large a margin. The only two that had the Univac I were the Census Bureau which was the first customer and the other was a military agency. GE ordered the third Univac I and was going to put it into the new Louisville factory with the idea to use it for payroll and accounting applications. GE was sure that they knew how to do payroll. No question of that. And so the Accounting Services group was going to take responsibility for designing and installing a payroll system, first in Louisville for the Washer and Dryer department. And they got help from Arthur Andersen. I think they had six, seven, eight consultants from Andersen, and they staffed it with Accounting Services people to do the programming work that was required to do the payroll.

And my boss, H. Ford Dickie or his boss or his boss's boss heard about this. And one of them said "Hey, they're going to put a computer in Louisville. Why don't we see what we might be able to do with the computer. Production Control has been working with a lot of punch card stuff going around the country. Let's see if we can do computer stuff." I guess there were eight or nine people on the Production Control Services staff. Since I had worked with punch cards, they asked me if I'd be interested in working on this. So I said sure. It sounded like an interesting thing. So because Accounting Services was working with the Washer and Dryer department, I had to pick a different department to work with.

<u>Programming the Univac I in Louisville</u>

I picked the Dishwasher and Disposal department and moved down to Louisville for three months with my wife and a couple of kids. I rented a house and started to program. I didn't have a lot of training and at that point, of course, programming was in machine code. There was no Assembler language. There was no nothing. The only good thing about the Univac I is that they used letters for the various commands. A was add and S was subtract and M was multiply and D was divide. That was a big help. Don't laugh. And the hardest thing was that we had to use absolute addresses. I had to keep track of exactly where everything was. There was no relative addressing nor any named fields or files. The basic storage was a mercury delay line, which took 200 milliseconds to go around. So if you were going to get any speed out of the machine, you had to know exactly how long each instruction was going to take. If you were doing multiply, you wanted to try and position where you were going to put the answer right about where you would be in the delay line or else you had to wait the additional 200 milliseconds. And to the extent that you did positioned things right you could get decent performance. But if you just placed the fields randomly, the calculations would take five to ten times as long.

Marcus: It was similar to the later drum machines.

Grad: Similar, but this was a lot slower. So, keeping track with all this was a major part. So there were two aspects of the job. I had a pretty good understanding of production control from having worked in Large Steam Turbine, but this was not a job shop anymore. I was now into a real production shop, an assembly line with a whole different sets of rules on how to set up schedules. Now you're producing to inventory. You're producing to a schedule. You have to bring in all your parts and everything on a timeframe. You don't have room for tons of inventory in that kind of factory. While it was not quite a just-in-time set up, it got very close to that. You had to really schedule all your incoming parts that way. You needed to have the bills of material for processing because there were a bunch of different models that you were producing of both dishwashers and disposals. You had to be able to do bill of material processing, parts explosions, set up the purchasing schedules all those kind of things. That was my job.

Over the next three months, I wrote all the programs for that department to be able to do the complete scheduling of the parts. I said "Gee, I think I've done a great job." But we had no computer in Louisville. There was no Univac I so I had just been talking to people about the procedures, getting the information and writing the programs. So then it was time to test out the programs and I came back to New York. A Univac I was installed at the Remington Rand facility on Lexington Avenue in New York City. This must have been in the fall of 1954. And Remington Rand had a machine and it was available at night. They were using it during the day for demonstrations and to make sales, but after five o'clock there wasn't anybody coming in and they had no use for it. So I came in at five o'clock every day and had the machine to myself; there was an operator who ran the machine and I sat there and ran all these programs I had written using test data I had picked up in Louisville. And that was until midnight every night to test the programs.

Well, I expected to get done in a few weeks and, it turned out to be three months later before I finally got finished. I found I wrote a lot of code quickly, but while I was very fast I was also very sloppy. It was very, very buggy code. Of course, you didn't have any debugging aids at that point, but that was something I hadn't even thought about until much later. I had the whole computer to myself every night. It was my machine. It was as though I had my own personal computer. There was nothing else on there. I had complete control. We could rerun the jobs as quickly as I wanted; I didn't have to wait in line for anybody or anything else.

Marcus: What was the I/O on that machine?

Grad: It had metal Monel tapes, which were very good, very high speed.

Marcus: So you used a Flexowriter?

Grad: No, no. For entry we used punch cards. Punch cards were being converted. With Univac you could actually go directly from punch cards to magnetic tape. They even had a tape writer where you could key in the information and have it go directly to magnetic tape. IBM did not have this but Univac did. But the main way was that you had punch cards. That's all I had programmed. We had punched over cards that you read and you put it onto the Monel tapes. The Monel tapes were heavy. They were very reliable, worked well, and the machines were good. The Univac I did not break down. Even though it was a vacuum tube machine at that point, it was pretty reliable.

Marcus: What kind of printing did they have?

Grad: They had their own printers but they were chain printers at that point. So you were dealing with a fairly sophisticated operation in that regard. I really remember their machines. Univac really had good equipment at that point. They were really leaders. IBM at that point was playing catch-up. So after three months, the program was fully debugged. We sent it down to Louisville and I believe that was the first application actually running when they installed the Univac I.

Marcus: So that was about three months to design and develop and three months to debug.

Grad: Yes. I didn't do much documentation I'm afraid. I don't remember what documentation I did or didn't do. But I'm told it did run for some period of time. I never really got back involved in Louisville. That was it, I turned it over to the Louisville people and I was on to other things. We were a Services group. We had trained some people down there by then and they were able to operate it. That was an incredible experience though in 1954.

Marcus: What did you do next?

Production Control Projects

Grad: When I came back to Production Control Services in New York City I started to deal with a whole range of things were available to me at that point in time. One of the things that was quite interesting to me was that GE had set up an operations research group under Harold Smiddy and he had working for him Mel Hurni, and they had gathered an absolutely top-flight group of mathematicians and operations researchers. During the Second World War, operations research had developed and been used for planning how we dropped bombs, how you set targets, how to do a whole range of things like that. And the view within GE was that we could apply that same kind of analytic and mathematical skills to business problems, either for products we might make or how to run our businesses better. What's the right route? If you were delivering appliances, how do you route the trucks? Which stores should they go to and in what sequence? You're going on service calls to homes. How do you do that? Those are some examples. There are all kinds of this type of business problems. How do you invest your resources? How do you best balance where how you pick between alternative products or projects? There were some terrific people. One of them was Walter Murdoch and I believe that another was Alan Hoffman. There were many people who became very well known later on because of their contributions.

These were very bright people, and they liked to have real problems to work on. And since I had a reasonable background in math and statistics and so forth, I started to talk to some of these people, got to know them and I gave them some real production control problems, problems to do with dispatching, problems to do with scheduling, problems to do with inventory control and inventory management. All of these are things were major issues in different parts of the company, whether it was an assembly line or a job shop. They were worth a lot of money to us if we could find ways to do them better and more efficiently.

So I got back into using mathematical tools to look at major problems in every department. For example, inventory control was an issue throughout GE. I spent a lot of time analyzing inventory control procedures and techniques. When do you reorder? How much do you reorder? You don't know exactly what you're going to need because this is all statistical in terms of what your customers are going to order. You're taking risks whatever you do. Carrying inventory is a cost, but lacking parts or materials when you need then may be a heavier cost.

So we set up tables and schedules and mathematical programs for inventory management, for purchase order size, for delivery timing, all of those kinds of things. I remember doing papers on the cost of carrying inventory versus the tradeoffs and those kinds of things.

One of the areas was how to schedule the work in job shops. Job shop scheduling has always been a mess, always difficult. How do you do it? Somehow, in about 1955, we started looking at how we might use simulation on computers to model a factory and be able to come up with better ways of job scheduling and dispatching. Alan Rowe was working in GE while he was working on his PhD. And then we had Dr. Harry Markowitz who, many, many years later got a Nobel Prize in economics. Harry was the head of this operations research group working with us in Production Control Services. And we were all trying to come up with different ways of using computers to analyze some of these scheduling and dispatching problems. We worked with Cornell University with a man named Conway up there -- I forgot his first name [it was Richard] They had built a simulation model that I think at that point was running an IBM rather than a Univac computer. We worked with them to set up the model of a job shop, a simulated job shop. What would be the best dispatch rules? We had recorded a whole set of data from some of our factories and Alan, for his Doctorate, was working on his idea with some very complex dispatching rules which sounded very logical and very rational.

But from my having been in a dispatch cage, I said "Let's try something for comparison. Let's try the shortest job first, regardless of the schedule. And once a day, let's take the job that's been there the longest and run it through." It could be twice a day, but the idea is, you ran as many little jobs through as quickly as you could. And then to make sure you didn't get too big of a backlog you took the longest job. It turned out that this simple set of rules beat the hell out of any of the complex rules that they came up with. It was amazing. We were completely nonplussed. Alan ignored these results and his doctoral paper used the complex rules to show how great it was.

There was dozens of these special projects. Analog computers were still in the ballgame at that point. We built an analog computer called the Productron and I wrote a booklet about this to get people to consider and use it. We may have built 10 or 20 of these just for use within the company. We didn't try and sell it outside. By this point, IBM had become a major player. GE did the payroll in Schenectady with an IBM 702 with a much smaller group of people running that project than the one in Louisville, with a fellow named Jim Pontius as the project manager, and they got their payroll running faster, better than the big project in Louisville. I think the Louisville project got all the key people fired because it cost GE 10 times as much as expected and it took them two years to do it. There have been articles published in magazines about the Louisville project. So we did a whole range of special projects all to do with production control and production management. And I worked with maybe 20 different departments all around the country during that time. Wherever I went -- let's say to the Syracuse electronics factories -- I knew a little bit of the terminology from my college courses and that was awfully helpful. I could understand what they were talking about. I could understand their problems and then I could apply some of the analytical and mathematical tools to improve their production control operations.

Marcus: As you went around to all of these places, you were within what organizational unit?

Grad: I was in Production Control Services and I was working as a staff consultant. The departments didn't pay for those services and I worked with the department people on solving their problems.

Marcus: And you reported to one single guy?

Grad: H. Ford Dickie. I worked for him the entire period of time. He was my boss and he reported up the chain of command to the Vice President of Manufacturing Services.

Marcus: How did you get reviewed and evaluated?

Grad: My boss did that. That was Ford Dickie. He looked at my reports. He talked to people I had talked to, and that was part of my evaluation process. That's what he did. But I didn't like him. I felt he was a four flusher, and that he would steal ideas from the people who worked for him and not give them credit. The good news was that we had a framework in which we could do wonderful stuff. For a little over five years, it was probably the most exciting period of my life in terms of work because of the nature of the projects. Everything was brand new. Everything was exciting. Everything was newly developed. Everything you did had never been done before and the tools we suddenly had in our hands were of such capability that we could do things that we never could realistically do in the past. For example, I saw my friend Bob Smiley out in Cincinnati when I went to the Evendale factory, which was the aircraft gas turbine plant. He was the head of accounting for that department by then. And Herb Grosch was working there using the IBM 704 and they were one of the leading people in doing scientific calculation work. So I got involved with them on some projects and we also used the 704 for some of the production control work there.

Another thing that happened was that every department wanted to get a computer, but they couldn't afford a Univac I or an IBM 702 or 705. So, a lot of them started getting interested in the IBM 650s and 305 RAMACs; and then IBM hooked up the RAMAC to the 650 and you could do some pretty good stuff, some pretty good sized operations. The biggest single application was bill of material processing, because that's what you have to be able to do for scheduling. Scheduling and bill of materials processing were the core applications no matter where you went, and so those were things I was working with many departments that I went to visit around the country. It was an exciting experience.

Also, during that time, while I don't remember the specifics, we gave the operations research people a lot of these inventory and scheduling problems and asked them what they might be able to do with them from a mathematical standpoint, what kind of algorithms they could put in place, that we could then program and use the computers to run. And that established some really terrific positive relationships for me with people that I ended up working with later at IBM. These were fascinating people and the dialog with them was so stimulating, I still remember Harry Markowitz and me, after a trip to one of the departments, standing on the platform at 125th Street in New York City, arguing about the details of one of these projects; we would have long, intense and creative debates. We then took the train home since we happened to be living in the same general area in Westchester County. But working with people with that kind of intellectual power was a wonderful experience for me.

Marcus: What happened next?

Integrated Systems Project at 39 Frame Motor Department

Grad: Well, out of all this, I can't remember when the idea first started. But one of the things that had bugged me for a long time was that each of the business functions was doing their own work. Engineering Services had their own projects on how to automate engineering. And Manufacturing Engineering Services had their projects. And Accounting Services had their own projects. And Marketing Services had their own projects. Everybody had their own individual things that they were doing and that struck me as being duplicative. On one of the production control projects, I came up with the idea of a cartoon character called Freddy the Freeloader. You mentioned before that you've seen Flexowriters being used; they produced punch paper tape as a byproduct of typing a document. The concept was that once you enter the data, don't enter it again. Capture it, reuse it. Once it's in machine readable form, make sure you reuse that same data instead of having Engineering produce the bill of materials and print it and then Manufacturing Control has to re-enter all that data. And so does Manufacturing Engineering. We have to re-enter all that data at each step. Then we finish with it and Cost Accounting has to re-enter all that data. It just seemed intuitively wrong to me and yet, the functional barriers were so strong, the question was how to cross those lines.

I think it was about 1956 or somewhere around there, maybe 1957, that I came up with the idea of what I ended up calling the Integrated Systems Project. The idea was that we should try to see if we could create a business system that integrated all the different pieces, starting from the customer's order being received – assume for the moment that it's not an assembly line where you're producing to a fixed schedule -- for something that is somewhat made to order and carrying it through from sales through engineering for design, into manufacturing engineering, how you're going to build it, into production control, getting the parts made, doing the purchasing, doing all the scheduling and the dispatching, to the quality control, to cost accounting, which would keep track of what all the costs were on the thing, and to the billing and shipping papers, the whole thing. I still don't remember how we sold the idea. I think Ford Dickie had a lot to do with the sale. We sold it up the chain through Manufacturing Services to our vice president, and he sold it across to the other vice presidents. And we were approved to start a project on that. We may have had help from the OR people, the Operations Research Service staff people. They didn't work on the project but they may have helped to encourage the idea. So we were approved to start a multi-function project, probably in early 1957.

We now had to find a department to work with. If you're going to try and come up with this system of how to do this thing, you have to have a place to demonstrate it. We checked around and we found a location in Ft. Wayne, Indiana which produced small motors. They made various kinds of small motors and one of these one was the 39 Frame Motor, which was made in that plant in Ft. Wayne. I put together a team, not a big team -- probably six or eight people altogether -- and I had a corresponding group of people in Ft. Wayne. I had an engineer on the team, I had a manufacturing engineer, I had a cost accountant, I had a marketing person on tap. We got someone from sales to give us input. I had someone from each of the services organizations plus a corresponding person from each function in Ft. Wayne from 39 Frame Motor. So we had a team with maybe six to eight people altogether. And we were going to go ahead and design a system that would integrate all of the information work flow from the time an order arrived, all the way until the product was built and shipped.

Marcus: Was this the first time that this was done at GE?

Grad: It was certainly the first time at GE and I've never seen anything in writing from any other source that would indicate that it had been tackled anyplace else. It may have been, but I don't know. And we called it ISP, the Integrated Systems Project. I seemed to always like to use three letters as an acronym. And we set up in Ft. Wayne. I was commuting to Ft. Wayne from New York every week and it was not the easiest thing in the world. We weren't talking about flying out at that point in time. I took an overnight train from the Croton/Harmon station on Sunday night and about five o'clock in the morning on Monday morning, the train stopped in the little town of Waterloo, Indiana, and a car was there to pick me up and take me to Ft. Wayne. I stayed there all week. Friday night I went home, got home on Saturday morning; spent Saturday and Sunday with my family; Sunday night, back out on the New York Central to Waterloo.

But the project went well. First we started by interviewing everybody.   "What is your job? What do you do? How do you do it? How do you know how to do it? How did you learn? What are the common elements? What are the common denominators?" We collected every blueprint we could on the 39 Frame Motors. We collected all the bills of material. We looked at a bunch of these motors and then we talked to the engineers. "Why do you have the rotor in this particular motor longer than that? Why do you have the oiling grooves this way? Why are the magnets this way? Why do you have the stand this way? What's different about this order that caused you to do that? What was in the order that you have drilled the base differently?" In 90% of the cases, there was no particular reason for differences. They just did it that way. There were five different engineers who designed these products and each one sat and did their own designs. They didn't have any easy way of finding the previous blueprints for similar motors and they never looked at them. It was easier just to do their own designs and let the draftsman draw them up, and write their own bill of material. So, you end up with little commonality.

But what we were able to do -- and this was what led to something that became very significant to me -- is that we asked them to talk through the logic with us. We would pull up the original order they had received. "What was it in that order that affected your decisions?" "Well, this one is going to be in a dirty climate. We had to put extra filters in." "This one's going to have high initial loads under certain cases. There was more resistance. We had to do this and this to the windings to make sure it could handle that." "This one was going to be running at a little bit higher speed because of what it was driving. We had to give extra lubrication, so we had to put more oiling grooves into the shaft." So we went through every piece, every part that was in those motors. That's not too complicated when we're talking about a relatively small motor, maybe 100, 125 parts. That was all. We were not tackling a very complex product. And it was something that we could mentally understand pretty easily.

The 39 Frame Motor was not a difficult product to understand. Here's an example. At the end of each of the rotors, which they called a shaft, is a chamfer so you don't have a sharp edge. So you beveled the edges. They had a dozen different levels of beveling. We said "Why?" They couldn't give us a good reason. So we said fine, we're going to standardize the beveling. The beveling is always going to be this, never anything else. Okay? So no matter what they come in with, I can design that bevel. I'm not going to think about it twice. The next thing did was that we went through the grooving. "Why is there a difference? What kind is it?" We needed just three levels of grooving and that was enough for light, medium or heavy duty oiling.

It was the same thing with the windings and with every part but the bases. There were real differences in the mountings so you had to do something more complex there, but the problem was, how do you record that more complex logic and how do you prove that it will handle any new order that comes in? After working there a month or so, I'm really stymied. If we write the logic as a computer program, no one's going to be able to check it out. If I write decision trees, no one's going to be able to check them out. If I write algebraic and Boolean formulas, no one's going to know what the hell to do with it. Whatever I write, I have to be able to have it checked by the engineers. And I had the same thing going on with manufacturing engineering. "Why did you decide to do this sequence with those kinds of jigs?" I had the same thing in cost accounting. I had it across the board.

At three o'clock one morning in a hotel in Ft. Wayne, I woke up with an "ah-hah" moment, a Eureka moment: Tables! I always liked tables. I always liked things in structured form. And I woke up and said, "If I put the information in some kind of a table format, I can get the cause/effect logic written down." Under these conditions, you do this. Under these conditions, you do that. And I can record it and someone can look at that table and see if that makes sense. I can carry them right through, column by column by column and say "Okay, under these conditions, is this what you would do? Under these other conditions, is this what you would do?" When I went to work the next day, I drew up the first of what I ended up calling Decision Tables. This was the way in which we were going to take all the logic that people told us and break it down, piece by piece by piece. It wasn't one table for the whole motor. There was a table for the shaft. There was a table for the windings. There was a table for the base and on and on and on.

By the time we got done with those tables, we saw that there was a chance to really simplify the designs and the manufacturing instructions. You didn't need to have these tens of thousands of different bills of material. We didn't need to have all these different drawings because there weren't going to be that many anymore. So we really felt we had made tremendous progress. We had all these pieces documented and you could see how you could go from the beginning with the order right straight through engineering, manufacturing, cost accounting to shipping and invoicing for the product. And then the project got canceled. There were changes in management at Ft. Wayne at the motor plant, not related to the 39 Frame Motor. But they had some serious business problems and we were told they couldn't afford to have us work there anymore, and we closed down. We'd been working there for about three to six months, and we were closed down.

Marcus: Was that the start of your work with Decision Tables?

Grad: Yes, that was when I created them.

Marcus: Did you create them out of whole cloth, so to speak, or was there something in your education or in your reading or whatever that planted a seed?

Grad: At the time, no. But the way I worked always was to set up some kind of a table with information in it, and of course, I'd had enough accounting background by that point, that I had worked on accounting statements. I like to structure every problem I tackle. I seem to set up some kind of a chart or a table to show the different things that I'm working with and how they interrelate. But no, there was nothing. Decision trees, Boolean algebra and logic, these were the things I had previously used to do logic.

Marcus: Spreadsheets with column headings?

Grad: Yes, that's the things I was used to, but I had never seen that applied to Boolean algebra or Boolean logic or to any of those kinds of logic problems. It may have been done before, but it was not something I was aware of. What is unique about the decision table is that it isn't just a table of information. The fundamental thing was that I broke the table into segments. You can think of it as two areas. The upper portion of the table above the double line lists the conditions; these are the values of the different conditions that would affect the decisions or actions. Below the double line are the decisions or the actions to be taken. So essentially each column is an if/then statement in a tabular format; and the whole table becomes a multiple set of related if/then statements in an easily readable format. Now, I did it with a particular format. You could do it the other way around with the conditions on the left and the actions on the right. But I did it from top to bottom. That was the way I thought.

Marcus: Did the electronic logic designers do something similar in terms of the Boolean algebra, build these tables?

Grad: That's an interesting one. I don't know if I had seen that at that point in time. It may have been.

Marcus: I'm not sure if they were doing it at that point in time. I learned about it much later.

Integrated Systems Project at the Meter Department

Grad: Certainly at that time, the engineers from Engineering Services who were on the project, some of whom may have come from electronics areas, did not bring anything like that to the table then and no one said "Ah hah. Oh, this is the way we do it." So Decision Tables were something we created in 1957, but then the project ended and we were going to put together a report on our experiences. However, I came back very enthusiastic about the potential for this integrated systems approach. It was there to be done and it was a damn shame we had to end the project. I don't remember how this worked out, but I was able to persuade my management that we should continue this effort, but we should pursue it on a much larger scale in a different department. And they agreed. And the people who had worked with me in Ft. Wayne brought back strong feedback to their management so we ended up with a team of 40 people on the next Integrated Systems Project effort. We were fortunate to find that the Meter department was interested. Previously we had motors, now we had meters.

Again, this was a semi-job shop. These are not the kinds of meters that are put on the side of your house to measure your electricity usage. These were being used on a steel roller mill or a paper mill. They were measuring something that was happening, and were all scaled to do that kind of measuring. This next project, which probably started in 1958, was in Lynn, Massachusetts. I was now managing a team almost 40 people from all these different disciplines. The team consisted almost entirely of people from outside the Meter Department. In this case, we were depending relatively little on the people inside the department except as sources of information. They were not an integral part of the team.

Marcus: So your team came primarily from the division to which you belonged?

Grad: No, the people came from each of the functional services and in some cases they got people from various other departments where they knew somebody who was very bright and interested in computers. They didn't have them necessarily on their own staff, but they borrowed people. For example, Stan Williams was borrowed from the Large Transformer Department in Pittsville, Mass. as the engineering guy. A fellow named Herb Neidenberg was borrowed from another department because he was a top flight manufacturing engineering guy. And Dan Langenwalter also came in on the engineering side. We had top Accounting and Marketing people. We were able to get these people from everywhere because by this point, there was more and more interest in computers and apparently people had heard about what we were doing and didn't want to be left out. That was very important to the other Services because if this was going to happen, they wanted to have a part of the credit and part of the benefit from it. And those years were pretty good years from a business standpoint for GE. There were no recessions so profits were pretty good. There was money available to do this. So now I started commuting to Lynn, Massachusetts.

Marcus: Where were you living at that time?

Grad: I was living in Tarrytown in New York. So every Sunday night, I would take the local commuter train down to New York City, would pick up the overnight train from Grand Central Station to go to Boston; sleep in a compartment on the train, get up in the morning in South Station and take a cab out to Lynn; get into the hotel and be at work for that week. On Friday night, I'd take the train back to New York. I would be home late Friday night, Saturday and Sunday; Sunday night, back to Boston again. Some of the people were staying in the Boston area and some of them were commuting. None of us were from that area. We had a few people from Schenectady, Pittsfield, and various other places, almost all from the Northeast.

We had a running start from the work we had done at Ft. Wayne, so this project picked up much more quickly. We knew what we wanted to do and we knew we were going to use Decision Tables for all of the logic on everything. We also decided to expand our study a bit. Before, we had restricted ourselves just to the information system. But in this case, we also decided to expand it to include the actual manufacturing processes themselves. By this time, numerically controlled machine tools were around. There were drill presses. There were lathes and milling machines. Typically these machines were being controlled through punch paper tape. And so we decided to at least look at that possibility while we were doing all the rest of the process to see if we could actually automate the manufacturing processes themselves and integrate at least some of them with the information systems, instead of just treating them as two separate processes. The project went well. We got a tremendous amount accomplished.

There were the same kind of results that had happened in Ft. Wayne; we found an incredible amount of duplication, where there was no particular reason why something was done differently. That's just the way it had been. You had thousands of different base designs and layouts for no particular reason; that was just the way it had been done. Some different engineer had done it, and he just put it in wherever he thought would be appropriate. There were numbers on the meter faces and what they were representing was different in almost every case. If you were doing a steel mill or a paper mill or whatever you were measuring, it was different in each case. So you knew that the meter face would have to be done to order. The typical cycle from the time an order came in to delivery was about three to four months. Costs were quite high, but the accuracy of the meters was pretty low. They were promising two to three percent accuracy. For many uses that was fine, it was not a big problem. But because you weren't delivering a very accurate meter, the prices were relatively low.

In many respects, the meters were fairly similar to the 39 Frame Motors with both electrical and mechanical components and maybe 125 to 150 parts. We followed the same study process by collecting all the available engineering and manufacturing and other materials, interviewing all the engineers, all of the manufacturing engineers, the cost accountants and so on and went across the whole board again. But this time, with the use of Decision Tables, we were very quickly able to get to the core structures on both engineering and manufacturing processes. We also came up with some new ideas. One idea was the use of a generic blueprint for each part and assembly. All these meters basically look alike. What is different is the specific dimensions and certain information like what's going to appear on the face of the meter. So, instead of every engineer having to produce his own blueprints and bills of material, and every worker in the factory who was doing any parts manufacturing having to get a blueprint related to that particular meter, we created a generic blueprint for every part.

Marcus: And they just had to put in the scaling, so to speak, the dimensions?

Grad: We even gave them a separate document that had all the dimensioning and special instructions, and we could print that off the computer easily. Drawing the picture by computer wasn't easy then. We didn't have any good graphical programs or printers. So the blueprints still were done by draftsmen. However, every dimension was code identified -- A, B, C -- and every characteristic was also coded, and then the worker got a sheet along with his work voucher which gave him all the dimensions that related to that part or assembly. So at each work station, you had the generic blueprint under glass or plastic, sitting right in front of you, and all you had to look at was this other dimensioning document.

We came up with completely different methods of doing the estimating of how much time it should take for each operation. Since these were now relatively standardized operations, we could figure out mechanically how much the worker should get paid for each voucher, because it was a piecework shop. We ended up by being able to do all of the information processing automatically; we could do the engineering, manufacturing engineering, production scheduling, cost accounting, quality control, billing, shipping papers and labels, the entire cycle from order from beginning to end, automatically. The basic cycle when we were done, even without any numerically controlled manufacturing, was going to take about a week, instead of two to three months.

In addition, we were also working on the two critical manufacturing steps that were really costing us a lot of time and expense. One was putting the numbers and other information on the face. They were pre-set up for each order, with the numbers located where the engineers thought they ought to be. The other critical process was the drilling of the bases. There were a lot of holes to be drilled. And for each one, there were different combinations of locations. We came up with two ideas as to how to solve these two manufacturing issues. Remember, this was an experiment, we didn't actually build the plant; we didn't take over the manufacturing process; we were just showing how it could be done.

For the face, instead of having them print the faces in advance using a photographic process as they had been doing, we came up with the idea that we would actually print them after we ran the meter. We'd actually assemble the meter, put in the different voltages, and determine where each of the key numbers was going to be located and then print the face with the numbers in those tested positions. By doing this, instead of having a meter with accuracy of two or three percent, you had one with a tenth of one percent accuracy, and the cost of production would actually be less. And with the base, we decided to use an automated punch tape controlled drill press. The punch paper tape will have the information as to the positioning of where each hole had to be drilled with what size drill. And since the numerically controlled drill presses had a magazine of drills, it could select not only the location but also which size drill and then drill to the depth specified in the punch paper tape. In this way the bases could be produced in a very short time, only requiring the operator to clamp the base into position and insert the correct punch paper tape into the reader.

Results of the Integrated Systems Project

Marcus: As a result of having a much more accurate product, did they increase the price?

Grad: Who knows what would have happened if they had done it. Remember, this was a study, an experiment.

Marcus: Was this in fact implemented?

Grad: To my knowledge, it was never done.

Marcus: So there are two instances in which there were sort of lost opportunities.

Grad: The story goes further. So we accomplished our objective. We produced a very elaborate set of reports on all these different ideas and solutions -- what would be done, how would it be done, how much would it cost to do, what it would require and so forth, and what the benefits would be. We were finished with the study. Now it was up to the people who wanted to implement these ideas. We all came back to our Services groups or to our departments with great enthusiasm. It took about a year, we were completely done, we felt we produced this great report, and everybody was totally enthusiastic about the results. We gave presentations and everyone congratulated us on the great job. And then I said to my management, "Well, that's fine, what do we do next? We've got to implement this. We can take these ideas and build a new plant, or take an existing one and modify it." GE was still having severe union problems in the US. So we said, "Well, how about building the factory in Puerto Rico?" And we even crated a basic new layout for the factory.

Marcus: Why did you pick Puerto Rico?

Grad: Puerto Rico was doing a lot of things at that point in the 1950s to encourage the growth of manufacturing there with lots of tax advantages.

Marcus: Was GE already doing things down there?

Grad: Some, not a lot, but GE wanted to do much more. There was a big labor supply, much lower cost, and there were a lot of tax benefits. Anyway, it was an idea. We could do it anywhere, but that was one thought. And we found one of the Vice Presidents in GE, who managed an electronic controls plant in North Carolina. He was running out of capacity and needed a new factory. So he said, "Hey, guys, can we do this for me?" So we worked with him. His name was Dr. Lou Rader and we came up with a proposed plant for him. But we were turned down flat by GE executive management. We were pretty upset about this, as you might guess. While I was the team leader, all these other guys really felt we had done something that was going to give a tremendous advantage to GE. So I really escalated my concerns: why isn't GE doing this? Eventually, Harold Smiddy, who was GE's Vice President of Management Consultation Services, turned us down. And his answer to me was, "We don't need to do this." I said, "What do you mean?" I'm paraphrasing but he basically said, "Well, look, we've got 60 percent or 50 percent of each of the major businesses that we are in, we make a good profit on the products, why should we bother investing the money?" That didn't make a lot of sense to me. I wasn't very happy about it, and I argued about it with my management, but after some more time, I finally said, "No, this is too frustrating, I don't want it, I'm going to have to get out, because I don't like it."

[Interviewee note: One sideline story is that shortly after I left GE at the end of January of 1960, Charlie Bachman joined GE's Production Control Services and actually took my old office at 570 Lexington Avenue in New York City. He then was the principal architect in a resurrected Integrated Systems Project, called ISP II, and was a leading member of the team (including some of those who had worked with me in Lynn) to strengthen the automation of the manufacturing control information process. This resulted in Bachman and the team focusing on the need for a well structured database management system to handle the bills of material and other manufacturing management files. This led to the Integrated Data Store (IDS} which became the foundation of Codasyl's database standards and was instrumental in the growth of the Database Management Systems industry. This work is described in detail by Charlie Bachman in the Annals of the History of Computing Volume 31 Number 4 starting on page 42]

Leaving GE

So I decided to start looking for another job, and I first looked at other jobs within GE. They had just decided to get into the computer business. Obviously that was of interest to me. I went to an interview in Phoenix where they were setting up the computer department headquarters. They also had a special operation in Santa Barbara called TEMPO which was doing special secret government work, which sounded fascinating at first. I also talked to some people I had met at IBM from working with them on some projects. After further discussions, neither of the GE opportunities sounded particularly appealing to me so I decided to take one of the offers that IBM made to me.

An interesting sideline to the story of GE not being interested in pursuing the results of the Integrated Systems Project was that at just about the time that I left GE, they were indicted for price fixing. The indictment covered many of the major electrical product areas. Apparently they were splitting the business in these products 60 percent to GE, 30 percent to Westinghouse, and 10 percent to Allis Chalmers. And the way in which they bid these project, since all of these projects went out for bid, was based upon the phase of the moon. And the formulas were such that they were priced based on the phase of the moon, and so in that way GE would get its 60 percent.

Marcus: To avoid doubt, what do you mean by the phase of the moon?

Grad: It really was the phase of the moon. That's what they used in the formula, so they would not screw each other over. So each company added a set factor to their pricing depending upon the phase of the moon.

Marcus: I see.

Grad: And that way they were sure that the market share would come out 60, 30, 10. GE and the other companies were indicted and later convicted for price fixing. And the Vice President of the Manufacturing Services Division was personally indicted, Arthur Vinson, and he was sent to prison here he died. He was heavily overweight, about 300 pounds, so that may have been a contributing factor. And the other thing that happened at about the same time, just after I left GE, was that they were also indicted for providing prostitutes for the dealers who were buying appliances from the Major Appliance Division. This gave my father the opportunity to tell me, "You see, nobody is honest," since I'd been telling him how honest the GE people were.

This really upset me, because we knew we had something that was significantly different. We tried to convince GE management, and we really went to the top through our Services connections, to try to convince them that they should take leadership in this area; this was their chance to really differentiate themselves. It would not just make their factories far more efficient than anybody else in every area, but they would help lead the world. And since they were just getting into the computer business, they would have a good thing to show. They could show how they were using their computers to do all this, not just to do accounting, not just to do manufacturing control, not just to do personnel. But our message fell on deaf ears. And when I decided to leave GE and go to work at IBM, I was told that everything I had done was secret, that I couldn't do anything with what I had developed; I couldn't describe it, I couldn't write about it and couldn't even use it in my future work. About three months later, my ex-boss, Ford Dickie, published a paper talking about the great things that he had done, how he had invented all of this stuff. That did not make me happy.

Marcus: This is while you were at IBM.

Grad: I was already at IBM then.

Summary of the GE Experience

Marcus: There are a couple of things I'd like to ask you about. For example, please talk a little more about Decision Tables, and sort of as an overview, cover some of the most important things you had done at GE.

Grad: I think that the thing that had the most significance was the integrated system concept -- the idea of integrating all of the business functions from an information processing standpoint. This is a theme that I followed through when I went to work for IBM. That was something that I talked about in my IBM interviews -- the idea that you shouldn't put together a series of independent functional solutions, but you should think of information processing as an entire system, going from the order to the delivery. And that you should look at the information system as a whole and not look at them as separate independent pieces. That was very, very important to me.

Also, while at GE I had written a number of papers and some internal books, which were not for external publication. GE did not encourage me to publish and would not really permit me to publish any articles outside the company. I wanted to publish what I had worked on in production and inventory control. I wanted to write about Decision Tables. But they wouldn't let me publish anything. That was the second thing that turned me off about staying in GE. I said, “Okay, if you're not going to implement the results of the Integrated Systems Project, then at least let me and the others publish what we've done. If you're not going to do it, if you don't think it's worth anything special, let us write it up.” I was convinced we could get good press coverage and that it would improve our professional status. And I liked the idea of publishing professional papers; that would be a nice thing. I hadn't done any professional publishing since the Dodge-Romig statistics paper, but the idea was very appealing to me. I was turned down flat. I was told that you are not going to publish this; this is secret, confidential, and you can't publish. And that was probably the final straw in terms of leaving the company.

Marcus: Do you have anything else that you think is significant in terms of what you contributed to GE, or to what GE contributed to you in your future career.

Grad: GE was an incredibly good company. The management skills and the management training were absolutely superb. The quality of the people in each of the departments was, in many cases, mediocre. Later on, as I worked at IBM, one of my thoughts, within weeks, was that if I had ten people like those I met at IBM in a GE department, it would have gone incredibly better. IBM just had better people, period. But at the time I was at GE, I was very impressed with the quality of their management training, the courses they put you through, the educational process; they were very, very professional, very thorough in this, and it was a wonderful experience. I went to all kinds of management schools; I learned all kinds of things, even though I was not a manager, except on the project basis.

Marcus: Do you want to speculate, if the company had these wonderful training programs, etcetera, etcetera, why people in their jobs didn't perform as well as they might have, or as well as IBM people did? There seems to be a dichotomy there.

Grad: You need to deal with this question on two different levels. I ended up feeling that any department in GE which had two or three top people was going to be successful; that's all it took. The businesses were fairly simple, fairly straightforward; each of them had a well defined niche, knew its niche well, had good solid products in that particular area and didn't have a lot of competitors. In every area, they were either number one or number two in that particular niche. Management people were very well trained. They really knew how to manage. They really understood the management process, the people relationships and those kinds of things.

During the 1050s GE had incredible union problems. They eventually got rid of the United Electrical Workers with some significant help from the government, because of the "Communist affiliation," and there was a new union that came in, the IUE, International Union of Electrical workers or something. They had big strikes with major, major problems. Lemuel Boulware was head of personnel for the corporation, and he was adamantly anti-union. He basically said, "Here's what we're going to give you. You can change whether you take it in medical, whether you take it in salary, whether you take it in pensions, but this is the size of the package, and we're not going to give you any more money." That fundamentally doesn't work in any kind of a real negotiating process, because the union people have to feel they got something, and he did just the absolute opposite. He said that he knew what GE could afford, and that's what we're going to give you. All you can do is change the shape. So it was a very difficult company in that regard. There was wonderful management training, they hired good people, but there wasn't a striving for excellence in the same way as I found in IBM.

Marcus: Was that a cultural problem, or was that the way in which they hired people? I mean was this a matter of the innate intelligence and work ethic of the people, or the environment in which they worked in?

Grad: The answer is that GE hired good people; they hired smart people, quality people. But they weren't necessarily the best people. There was that difference at IBM. Somehow IBM got the absolute cream of the crop, and I don't know why that was different, but they got the top ten percent, and GE got the next ten percent of the graduates, and I don't know why that was; I don't think it was salary differences, because IBM wasn't overpaying particularly. The thing I've thought of before and I don't know if this is right, is that IBM was essentially a marketing company. It thought of itself as a marketing company. It had fine engineering, fine research, fine all these things, but the sales people were the ones who drove the company; the sales people were the ones who went to the top of the company. And you had a clear sequence between Tom Watson Senior and Tom Watson Junior; there was a very, very clear management reward and executive selection scheme.

GE also had good top executives, from Charlie Wilson to Ralph Cordiner, and it continued to afterward. But they were more financially driven. They were more rules driven. Maybe it was the nature of the business. Having 100 different product lines changes the character of a business. You don't have a driving force, an integrating force that pulls it all together. It just was different. You just didn't have as many good people. I don't know why, and I never realized it at the time I worked at GE. But the operations research people were the absolute best in the country at that point. They were comparable to what the Ford Motor Company did. I I don't know if you remember, but Ford Motor Company brought in what were called the Whiz kids after the Second World War including Robert McNamara who was later the Secretary of Defense. Those were the same kind of people that were in GE's Operation Research.

But they didn't influence the company in the same way that IBM's leading people did. They just solved specific problems, whereas, when those kinds of people worked for IBM, they helped to influence and change the direction of the company. But I know that I had the privilege of working for two incredibly successful and outstanding companies, for GE, and then with IBM. What I learned from the GE experience was of unbelievable value to me, specifically the stuff I did on ISP, and that's exactly what I started doing at IBM; within weeks, literally, of being hired there, I resurrected the ideas that I'd been working on.

Marcus: So, what stands out to me so far in what you've described as things that you took forward, was this holistic systems oriented approach, as opposed to a functional orientation.

Grad: And I took Decision Tables with me. The integrated systems approach and Decision Tables were both a major part of the work that I wanted to do, but at that point, remember, I had never been a manager. I was a project manager, but that's not the same thing as being a manager of a business unit or function. I had been to the training courses, but I had never been a manager. And within about a month to six weeks of my joining IBM, I became a manager of five people for the first time.

Marcus: So, did you think you learned a lot of business management skills at GE, even though it sounds like they didn't encourage business thinking, because they didn't adopt some of these clearly good ideas?

Grad: That's not a fair statement. There was clearly a great amount of emphasis on the business aspect and business view for the general managers of each of the divisions and departments. That was clearly what they were trained to do. But I was in a staff role. And I was supposed to deal with staff technical type problems, analytics, and it was just different. As I say, I don't know how I would have functioned as a manager at GE; I think I would have been okay, but I had never managed people; I was never a true manager in the sense that I ended up being at IBM.

Marcus: You indicated that at one time in your career at GE, you ran into some problems as a result of the way in which you were dealing with people. And somebody was good enough to bring that to your attention. Do you think that, while at GE, that skill improved?

Grad: It improved, but I still was relatively pushy in terms of getting things done and pushing people where they didn't want to go sometimes. There was one man, I remember, who was also in Manufacturing Services. He happened to be in what was called the materials control area, which included purchasing, and his name was Youngblood, and he could get things done. He had this persuasive ability. He got things done not by pushing, but by persuading. And I learned from people like him to try and do more of that. And I think that when I ran those last two projects at Fort Wayne and then in Lynn, those were the skills that enabled me to be a project manager, and a successful one, because the people all felt that they were part of the team, they were helping make things happen. I wasn't telling them what to do, but I was helping them do what needed to be done. So I think that made a difference there. Anyway, those 11 years at GE were exciting wonderful years, and those last few years, working on the integrated system projects, were just mind boggling in terms of the number of new ideas that kept coming up. I always felt that that was, in some technological sense, the high point in my life, and while this led to other really creative ideas, that was really the most creative time.

Marcus: You were one of the authors of a book on project management.

Grad: *Management Systems* was the name of the book.

Marcus: Most of the discussion we've had here has focused on relatively small projects, as opposed to very large projects, or projects of great length in terms of time. Subsequently at IBM, I think you managed much bigger things. Was there anything at GE that contributed to your ability to successfully manage really large projects, and to author a book on project management?

Grad: The book isn't really about project management. The book is really the extension of the idea of the integrated systems project. The idea was, design your systems to go from beginning to end. The management systems book really describes a whole process for doing that. I'm very process oriented, so the book went into how a system should be designed. While I was a manager of a fairly large number of people at times at IBM, I really felt my skills were more project leader oriented. I was a person who could pick a major area we were going to work on, and I would work with the people to make that happen. I never felt that I was a really good manager in the sense that some of the people at GE were, or some of the people at IBM were. I wasn't as good a people manager; I was better project manager in that sense. But the book had nothing to do with project management. I worked on that for other reasons. It had to do with the systems you should build to run your business. So let's talk about Decision Tables for a bit.

Decision Tables

Marcus: Well, it's an incredibly valuable tool; how did it get into the general domain because so many people used it, and yet GE didn't want to allow you to publish?

Grad: Well, this is a mixed bag. Decision Tables in my opinion would still be a useful tool for developing and describing any complex logic, and explain it in a way that people can check it. It is a tool which is capable of being self checking, of knowing whether you have completeness, knowing whether you have consistency, knowing whether you have gaps, whether you have overlaps. It's mathematically provable, where most of the other logic forms that we use really have that characteristic to them. The Decision Tables are also readable which is helpful. Let me talk a little bit about what we did with them after we came up with the idea.

Marcus: At GE, or elsewhere?

Grad: At GE.

Marcus: Okay, that's fine, but I'd also like to hear how this got into the general domain, if possible.

Grad: Okay, I'll come back to that. Essentially, once we came up with the idea, remember, we didn't have any electronic tools to work with. This was all hand work, and all done manually. You draw horizontal and vertical lines on a sheet of paper or you use accounting sheets, and then you start to fill in what the conditions are related to the particular subject area; you then fill in what results or actions you're going to take. If it's a part being designed, you note what dimensions need to be specified, for example. Then you try to come up with all the combinations of conditions that might affect your decision process, so you're spreading it out across the page, setting up each column. And then you find out that you left out a condition, so you've got to put in another condition. Since you need an extra column, you split a column in half and try to write small enough to fit into the new column. The mechanics were very difficult. The other limitation was that the individual table can't get too big, because your mind doesn't encompass it, and the paper isn’t big enough. So you want to stay within a size you can work with.

When we did the engineering logic, it was relatively straightforward. You essentially set up tables for each part that was in the product. What were the conditions that enabled you to select which of those different alternatives you had for the different screws, the different bolts, the different nuts, the different templates, the different windings, the different shafts, whatever you were working on? If the order says this, if the order says that, if the order says the other, then I do this. And for each of those cases, you try and put down what you can think of. The physical mechanics of laying out a table was always a real barrier.

The second point, of course, is, now I've got a table laid out, I've got to connect it to another table. So I've got a sequence mechanism. Under these conditions after taking these actions, you go to table three; under these other conditions, you go to table seven and so on. Therefore, you've got to keep track of all of those sequences, so you need a master table that keeps track of where you are. Then in each table you need to check to see if you've laid out every possible combination, and you've included all of the possible values for each condition in the columns. In other words, if A equals 7 to 10, you do this. If A equals 10 to 12, you do that. We put actual values in each column; that was the way we did it. Other people developed Decision Tables just a short time later, where they made each condition a question which could be answered yes or no in the column. This is often a better way to do the logic, but at the time I was thinking in terms of dimensions and physical measurements, so that was initially a more logical way for me to think it through. Then we had to determine how to convert this Decision Table into a computer program. How do we get something to actually implement what we have just written the logic for? So we went to work, actually with the Computer Usage Company (CUC), to do the implementation.

Marcus: We, meaning while you were at GE?

Grad: Oh yes, this was all GE, in about 1957, and CUC assigned Jill Kelly (she married a little later and became Jill Arbuckle) and George Trimble was her boss. I was working with both of them to build a program that would take the Decision Tables that we wrote and, after keying in the conditions and values and the actions and their values or formulas, the program would produce actual code that would run the tables and produce the desired results. So you put the inputs in, the tables would run, and you would have the part designed producing the bill of material, the dimensions for the parts, the manufacturing instructions; it was all done. So we had that working in late1957 or early 1958. CUC produced that program. I think they may have used a 305 RAMAC, or a 650 RAMAC, if my memory serves me correctly. And the program was called TABSOL which stood for Table Solution.

Marcus: Now was that something that CUC then took forward?

Grad: No, it belonged to GE.

Marcus: So again, we have a barrier to this getting to the external world.

Grad: GE did eventually release TABSOL as a software product on the GE 225 in the 1960s. And TABSOL actually ran on other machines. TABSOL got out into the world. Tom

Kavanagh who was also in Production Control Services worked with me on that, and he was the one who took that over at GE when I left. TABSOL did get into the marketplace, but it never sold a lot, but it was available as a generalized program. But the translation of the tables into programs was really just the tip of the iceberg in a sense. The problem was that creating the tables was a slow process. Without the ability to design and build a table online, it was too difficult a manual process. If you could have sat in front of a screen and build the tables, then you could have modified them easily and you would have the information already entered into the computer. I don't know whether that would have made a difference or not. Decision Tables had quite a bit of attention during the 1960s into the 1970s and 1980s, and are still being used occasionally nowadays, but they sort of disappeared by the 1990s. Other kinds of tools like decision trees ended up being used. But I still don't think that any of those other tools have the same characteristics as Decision Tables.

One of the things I talked about in my IBM oral history interview is what I later did with the mathematicians in IBM Research, some of whom I had worked with at GE. We developed algorithms for automatically checking, automatically sequencing the tables in such a way as to produce most efficient programs. Because you could keep track of how frequently certain conditions occurred, how often certain columns were used and things like that, you could rearrange the sequence of running the tests so that your programs were actually much more efficient. Remember, in the early 1960s, solution speed still made a difference. Nowadays, maybe at the computer speeds we have, it doesn't matter much. But at that point, you could make a big difference in terms of how long it took to come up with a result. We used them in different places. There were books written on Decision Tables. I wrote a preface to one of them, but I was never interested in writing a book myself so I didn't do so. And a fellow named Orrin Evans at the Sutherland & Company working on an Air Force project had also created Decision Tables in 1958. I think he called them logic tables. And he was the one that did the yes-no model; in some ways, that was a more efficient format, because you could just put a one or zero in each box, and in terms of compactness of representing the logic, that was easier than putting actually values into each of the cells of the table. [Interviewee note: there is still a company offering a decision table processor; it is called Logic Gem and the company's name is Catalyst Development]

The Computer Business at GE

Marcus: During the time that you were at GE, or maybe even later, do you want to comment on the role GE played in the computer systems business?

Grad: By the time I left, it was really not very significant. They had taken over responsibility for the Bank of America project, developing the ERMA computer, which was a massive machine. Bank of America was going to use it for its teller operations and other bank operations functions. Joseph Weizenbaum was the leading force in that development, and Joe became quite famous later on for his development of Eliza, which was a pseudo psychiatric kind of program where it appeared that the computer was interviewing people in a questioning mode. Joe was working at that time on a whole range of things in terms of artificial intelligence, and he was trying to show, with Eliza, that there was a way to, in effect, come up with logical human interaction with a machine. He later on turned against the artificial intelligence concept and community, and became one of the greatest opponents to artificial intelligence; he was castigated and ostracized by the whole AI community. He died, I think just a year or so ago in Berlin [2009].

So GE picked up the ERMA project and then started to develop their own machines. I'm trying to remember whether they worked with NCR or not, but I remember the GE 304, or some such number, was involved. It may have involved a whole line of machines. But GE was never very successful as a computer manufacturer. And I think one of the reasons they weren't successful was they were in too many businesses. IBM focused on computers; they were just in one business. One could argue that Sperry Rand made the same mistake. They were in too many businesses; they didn't focus on the Univac. And RCA had too many divisions. These companies just didn't focus enough on computers, and their management was distracted. IBM was not. GE wouldn't invest the big money, and never had the skill set in their own computer division to match IBM. And of course, GE never had the marketing or sales capability of IBM. IBM's marketing force was incredibly strong, and you could argue that Univac lost out because of that. They lost out for other reasons, too, but Univac didn't lose because of technical reasons.

Marcus: When GE and IBM were competitors, what was GE's relationship with IBM in terms of its use of IBM's equipment and any cooperation with IBM?

Grad: That’s an interesting question. They were still a major customer of IBM, and yet as the 1960s wore on, they started to try and use more of their own machines. They developed their own operating system, called GE-COM; they did a whole range of things to build their market share. But they became one of the seven dwarves, and all together they amounted to about 30 percent of the mainframe business, while IBM had 70 percent. It’s hard to try to explain the difference in retrospect, except that IBM devoted all of its energy to computers. Here’s an example. IBM spent 5 billion dollars to develop the System/360. They bet the company on it and it worked. I don't think GE or any of the other competitors would have spent a tenth of that. So, unless you are willing to take big financial risks you're not going to keep up with IBM. The System/360 really ended the battle. By 1964, when IBM announced the System/360, IBM was already the leading company, but they had seven different product lines, and therefore, in a sense, they were exposed. Anybody could come in against any one of those product lines, and pick up a chunk of the business. For example, who was it, the Liberator, came from which company?

Marcus: Was that Honeywell?

Grad: Yes and this imitated the IBM 1401. Honeywell gave the customer a 1401 lookalike at a 30 percent discount.

Marcus: Well, and RCA produced the Spectra 70 which was a System/360 emulator.

Grad: You're right. It was the same kind of a thing, exactly. IBM's ire was pretty high on the Liberator, but the point was, if IBM had stayed exposed like that, I don't know that they ever would have had the level of domination they ended up in the late 1960s and 1970s. And GE just fell by the wayside. They eventually sold their computer business to Honeywell which continued to sell the GE computers for some time until they sold the computer business to a French company, Groupe Bull.

Marcus: Well, Burt, if there's nothing else to add, thanks for the time, and for the really interesting background.

Grad: Thank you very much.

